

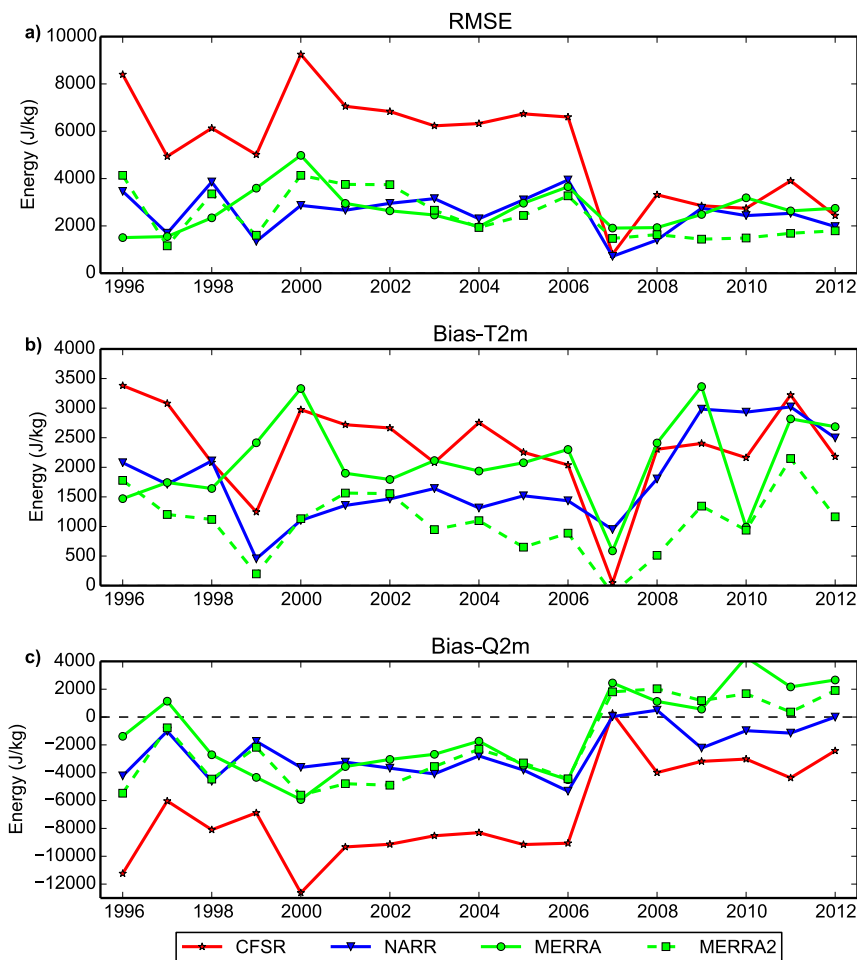


Land-Atmosphere Coupling in Modern Reanalysis Products

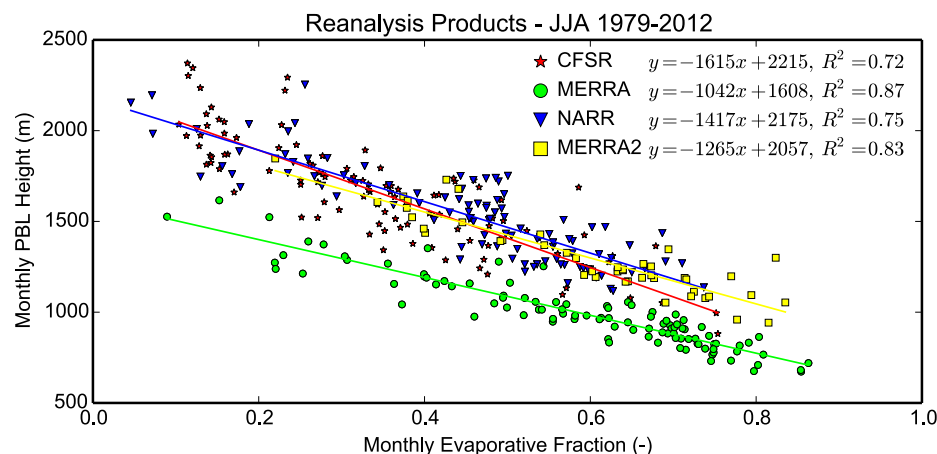
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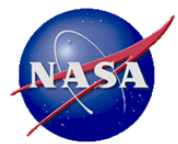
(1) Reanalysis Errors over the U.S. SGP



(2) Relationship of Evaporation to PBL Height



An integrated assessment of land-atmosphere (L-A) interactions in current reanalysis products highlights important differences and varying accuracies in each, and suggests that updates to MERRA-2 (vs. MERRA) have led to improvements in the representation of L-A coupling.



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References:

- Santanello, J. A.**, J. Roundy, and P. Dirmeyer, 2015: Quantifying the Land-Atmosphere Coupling Behavior in Modern Reanalysis Products over the U.S. Southern Great Plains. *J. Climate*, **28**, 5813-5829.
- Santanello, J. A.**, C. D. Peters-Lidard, A. Kennedy, S. Kumar, and S. Zhou, 2013: Diagnosing the Nature of Land-Atmosphere Coupling: A Case Study of Dry/Wet Extremes in the U.S. Southern Great Plains. *J. Hydrometeorol.*, **14** (1), 3-24.

Data Sources:

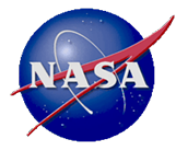
- Reanalysis Products:** **NASA's Modern-Era Retrospective analysis for Research and Applications versions 1 (MERRA) and 2 (MERRA-2), NCEP's Climate Forecast System Reanalysis (CFSR), and NCEP's North American Regional Reanalysis (NARR)** data were acquired at 1 and 3-hourly resolution and include 2-meter temperature, humidity, boundary layer (PBL) height, and surface latent and sensible heat flux. These were then averaged over monthly and seasonal (June, July, August) timescales to produce the yearly JJA values (1996-2012).
- Surface Observations:** **Hourly surface meteorology, flux, and soil moisture data** were acquired from the new Atmospheric Radiation Measurement Southern Great Plains (ARM-SGP) Land Best Estimate (ARMBE-Land) product, and then averaged over monthly and JJA period from 1996-2012. This product was generated specifically for the PI and GEWEX-led LoCo working group investigations.
- PBL Observations:** **Planetary Boundary Layer (PBL) profiles** obtained from the new MERGESONDE product from ARM that is comprised of a combination of observed radiosonde data at the SGP Central Facility temporally interpolated to hourly resolution using the ECWMF reanalysis (ERA-Interim). PBL height was calculated from temperature profiles using a Bulk Richardson approach and averaged over JJA.

Technical Description of Figures:

Figure 1: Summary statistics of **a) root mean squared error (RMSE) of total energy (J kg^{-1}), b) 2-meter temperature (T_{2m} ; J kg^{-1}) bias, and c) 2-meter specific humidity (Q_{2m} ; J kg^{-1}) bias** from each of the reanalysis products over the 1996-2012 period as compared to observations over the SGP region. Statistics are derived from **local land-atmosphere coupling (LoCo) diagnostics** and are reflective of the cumulative error in land-atmosphere water and energy budgets in each reanalysis as governed by simultaneous assessment of both land surface and atmospheric fluxes and states.

Figure 2: Monthly mean (JJA) values of **daytime evaporative fraction (EF; -) versus maximum PBL height (PBLH; m)** over the 1996-2012 period. EF and PBLH represent integrative endpoints of the coupled land-atmosphere system in that EF integrates the surface soil moisture signal and latent/sensible heat fluxes into the atmosphere while PBLH is indicative of the atmospheric/PBL response, growth and entrainment feedbacks back on the coupled system. MERRA-2 shows larger PBLH values and sensitivities to EF that closer to CFSR and NARR.

Scientific significance, societal relevance, and relationships to future missions: For the first time, LoCo diagnostics have been extended to global model (reanalysis) products to assess the land-atmosphere coupling of diurnal water and energy cycles at interannual timescales. This process-level quantification of coupled processes is critical to model evaluation and development. CFSR is inherently dry biased over the region, while MERRA performs best and MERRA-2 improves even more relative to observations. This is a result of changes to the land surface and PBL schemes in MERRA-2. How each model responds to extremes (e.g. 2006 vs. 2007) is important to assess the full capabilities of land and PBL physics. While limited to the SGP region, this study demonstrates how integrated assessments can be made of complex modeling systems, but at the same time require a well-instrumented region (e.g. ARM-SGP) that includes PBL profiling (currently a gap in our satellite retrievals).



Measuring the Directional Variations of Land Surface Reflectance From MODIS

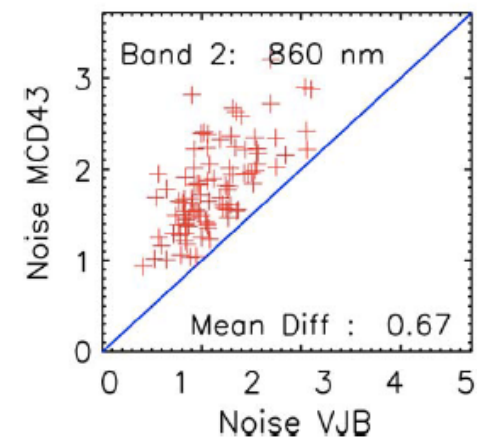
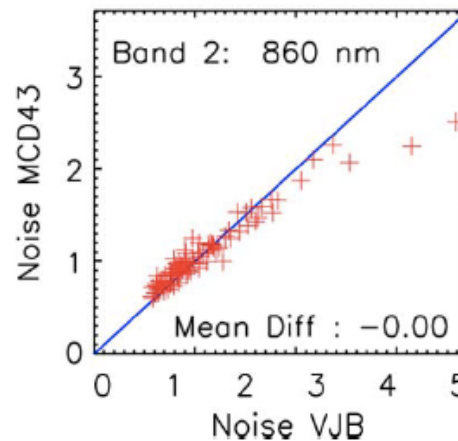
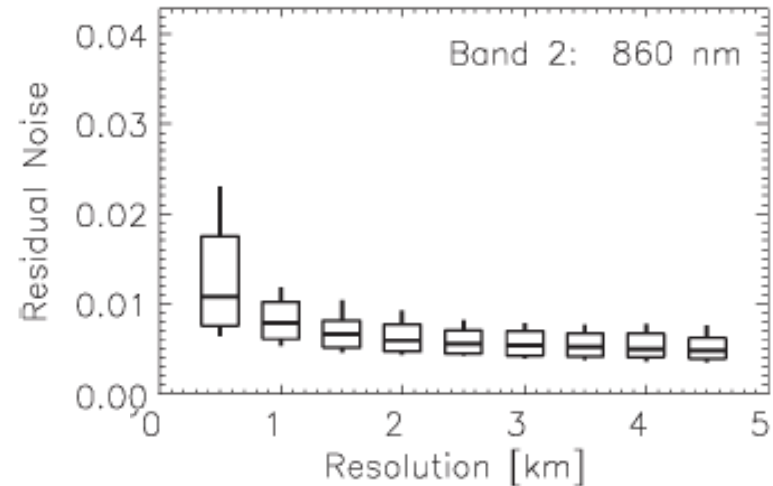
Eric Vermote, Terrestrial Information Systems, NASA GSFC

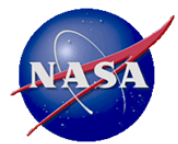
Using MODIS, we have shown:

that a reduction in noise and a more realistic representation of the surface BRDF shape can be obtained from a 2-km product, as compared to full resolution (500 m) due to the broad swath-width,

and

that the VJB approach to generating the BRDF (Vermote et al., 2009, Bréon and Vermote, 2012) is better than the method currently used (MCD43) by providing a more reliable model applicable for observation geometries that are significantly different than those of the acquisition set.





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Abstract:

The directional variation of land surface reflectance generates an apparent noise in the time series acquired from satellites with variable observation geometries, which can be corrected through appropriate modeling of the bidirectional reflectance distribution function (BRDF). In a previous paper, we described and validated the VJB method that estimates a target BRDF shape and corrects for directional effects and yet retains the high temporal resolution of the measurement. Here, we analyze its potential to measure the BRDF of targets at the 0.5-km resolution of Moderate Resolution Imaging Spectroradiometer (MODIS). The description of the BRDF in the NASA MCD43A1 product shows very large temporal variations that are unrealistic. However, the reflectance time series, normalized to a standard observation geometry using this modeling, have a similar quality as those derived using VJB. Conversely, the MCD43A1 modeled reflectances for a nonstandard geometry are unrealistically variable. These results indicate that the standard BRDF model inversion used to derive the MCD43A1 product is underconstrained due to the limited directional sampling of the 16-day composite period. The apparent noise in the corrected reflectance time series is significantly larger than the one obtained at lower spatial resolution, and is very much a function of the spatial heterogeneity of the area surrounding the target. These results strongly indicate that the multitemporal MODIS measurement at high spatial resolution (0.5 km) is affected by a change in the effective resolution for off-nadir observation and by inaccurate registration. The resulting noise in the measurements precludes an accurate measurement of the BRDF at such a scale

References:

Vermote, E., Justice, C. O., & Bréon, F. M. (2009). Towards a generalized approach for correction of the BRDF effect in MODIS directional reflectances, *IEEE Transactions on Geoscience and Remote Sensing*, 47(3), 898-908.
Bréon, F. M., & Vermote, E. (2012). Correction of MODIS surface reflectance time series for BRDF effects. *Remote Sensing of Environment*, 125, 1-9.
Bréon, F. M, Vermote, E., Murphy E., Franch B. (2015). Measuring the Directional Variations of Land Surface Reflectance From MODIS, *IEEE Transactions on Geoscience and Remote Sensing*, 53,(8),4638-4649.

Data Sources: The MODIS surface reflectance product is being tested and generated by Code 619.

Technical Description of Figures:

Figure 1: (Top) the noise in the BRDF corrected data is drastically improved when coarsening spatial resolution, this is simply due to growing size of the pixel as a function of view angle. (Bottom) comparison of the performance of the VJB correction (Vermote et al., 2009) with the standard MODIS approach (MCD43), for geometry close to the observation (left) or further away (right).

Scientific significance:

Continuous and systematic high quality Earth Observations from NASA satellites provide the critical synoptic and objective information needed by applications of societal benefit in the context of growing population and climate change.

Relevance for future science and relationship to Decadal Survey:

Demonstrating how to use current sensors to understand our changing planet and delivering those data to the global community is part of NASA mission and is critical to develop future missions and sensors to further improve other government agencies and partner organizations decision-making.